

# DEVELOPMENT OF NATURE STUDIES AND TECHNOLOGIES COMPETENCE IN THE CONTEXT-ORIENTED PROCESS OF LEARNING PHYSICS

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## **Theoretical Analysis of Physics Learning Process in a Context-Oriented Constructive Pedagogical Process**

In the Part 1 of the monograph scientific literature about the guidelines of constructivism, context, the use of didactical reconstruction in teaching physics, neurocognitive learning theory, methods of neurovisualization has been analyzed, the curriculum of overall secondary education of physics and the possibilities of using elements of bionics in physics learning process have been analyzed.

**In the chapter 1.1**, by summarizing acknowledgements analyzed in different sources (Piaget, 1970; Bruner, 1996; Geidžs & Berliners, 1999) the authors conclude that the ideas of constructivism that are based upon cognitive theories, help the student to construct his/her own knowledge by noticing the difference between previous knowledge and new experience. Students improve their intellectual capabilities by seeking the balance between what they perceive, know, understand and what they see in every new event, experience or problem. If the student creates and verifies hypothesis on his/her own, experience in formulating overall laws and principles, identifying useful terms is generated. It is important for students to understand the topic being taught correctly, the understanding is based upon the abstract and the defined, a uninterrupted connection between the overall and the specific.

The main principles of constructivism are summarized in Table 1.

Table 1 **The main principles of constructivism**

<b>Principles of constructivism</b>	<b>Description of principles</b>
Construction	Formation of knowledge by activity, action, problem solution
Understanding	The learning process is focused on thinking and formation of understanding
Context	Problems are solved, tasks are approximated to the real life and professional activity
Cooperation	Mutual assistance in problem solution, evaluation of ideas
Communication	Development of communicative skills through communication in group work, projects, formulating own ideas, asking questions
Responsibility	A pupil feels responsible for his/her learning from the moment when his/her learning is based on his/her questions, discoveries, and solutions
Transfer	Discovering own learning principles a pupil can apply them in other learning situations
Emotional experience	Emotional experience causes activity of cognitive processes, urge mind activity. Emotional experience is created by application of diverse, active forms of learning

**The chapter 1.2.** includes two subchapters.

**In the subchapter 1.2.1.** the conception of context in physics is analysed. Physics education is important in realization of valuable everyday life, in training for professional activities and in development of worldviews and attitude towards the surrounding world. The fact that pupils can relate the learning content to be studied with their lives, thus being more motivated for the schoolwork, is an advantage of physics learning. The knowledge to be acquired in the learning process may be applied in real life situations and physics may be studied by analyzing these situations. On the basis of the aspect mentioned, it may be concluded that learning content of physics shall be viewed within the context. It means that learning content is related to the phenomena of everyday life, possible future career, elaboration of technical devices, or it is viewed within historical context of physics and as the influencing factor of technology development, society and its cultural achievements.

The word context comes from the Latin “contexere” which in translation means “to be weave together” or “that which gives coherence to its parts” (Cole, 1996). General definitions underlie the concept of context; therefore, spheres of origin of contexts shall be discussed in order to comprehend the essence of this definition completely. The origin of contexts which are used in physics learning

process is related to the personal, social and professional sphere, as well as to the scientific and technological sphere (Jong, 2006). Analyzing teaching strategies mentioned by F. Villalino, the contexts may be divided into five groups: context of life experience, cognitive context, context of knowledge application, cooperation context, and context of knowledge transference. The usage of the contexts of these groups ensures complete and varied physics learning process. O. Jong has classified contexts into groups according to the aspects of their usage (Jong, 2006). This classification includes the contexts which are used in the acquisition of theoretical issues and after explanation of theory, contexts which complement the content of teaching materials, encourage the application and summarization of knowledge and promote further investigation of issues.

By analysing the acknowledgements of different authors (J. Brunner, V. Klafki, R. McDermot, J. Mestre, E. Clark etc.) about context oriented learning the author concluded that context contains qualities that promotes the creation of the perception of content. E. Clark (Clark, 1997) interprets the context as over-content that helps define a meaningful understanding about what is taught concerning every day phenomenon: culture, politics, economy and ecology. Clark defines four fundamental types of context: subjective context, time context, symbolic context and the context of ecosystem or the global context. In the centre of attention of contextual constructivism are contexts. Context is one of the most important parts of learning process and not a separable factor. By connecting the curriculum with happenings of the real world, everyday lives of students and teachers, professional activities and career, the physics learning process becomes interesting and meaningful, it drives students to be more active and self-motivated to study.

**In the subchapter 1.2.2.** it is concluded that physics teaching is mostly centred around students and the curriculum, student's understanding of the world is developed in the teaching process. To develop a scientific understanding of the world in students, that is based upon previous knowledge, one must understand how students develop intuitive theories about the world. Learning is not an isolated activity but a social activity that is influenced by local contexts – the information about the task, the situation and the environment. These contexts are not analytically separated, but are very important for the learning process of the student. From this viewpoint a conceptual change happens both in the student and the context. Environments where context encourages the learning process should be created. Abstractions, that will allow the student to use this conception in other situations. Are connected to these conceptions. Environment has to promote both

the conceptual understanding of the particular situation nad the ability to transfer this knowledge to other, connected situations (McDermott, 1993).

Context aids the formation of a meaningful understanding about the things that are taught and are connected to the happenings of everyday life, bionics. The contextual approach stimulates the development of the cognitive competency, the skills of using knowledge and the learning motivation and attitude. The application of principles of physics to different situations, by providing a more precise reflection of acquired knowledge in practice can be achieved with the use of contexts. Students build their understanding of the content in context and that cannot be separated from the student's learning context, in which it happens and how it corresponds to the basics of contextual constructivism. According to the acknowledgements of different authors, contextual aproach in physics content and the process of organizing can be applied in three aspects – conceptual, thematical and methodological. Contextual aproach creates the need for the creation of integrated physics curriculum, by noting the idea of interconnection, in order to give each student the opportunity to build his/her own meaningful understanding about the world and one's role in it.

A student tries to comprehend the surrounding world and, in order to do that, develops an understanding of science, technologies and society during the learning process. A student explores the nature, artificial man-made environment and social environment. Context-oriented approach emphasizes the relation between science, technologies and society in physics learning process. This approach declares studies as the process, within the framework of which a pupil acquires new information in the context of meaning, searching for sense and usefulness (Rose, 2012). Strategic learning elements – to relate, to experience, to apply, to cooperate, and to transfer – are expressed in context-oriented studies.

Several problems, which are related to the activities of a teacher and pupils, may be distinguished in the implementation of context-oriented studies:

- professionalism of a teacher during the implementation of context-oriented approach;
- choice of varied contexts which correspond to the issues of learning content and pupil's abilities to comprehend and understand;
- generalization of pupil's knowledge beyond the context;
- usage of contexts which reflect the learning context but may have negative emotional influence on the pupil.

The problems mentioned above can be solved by offering appropriate professional development programs for teachers, elaborating appropriate

methodological teaching materials, realizing an integration of various types of activities in the learning process, using well-known examples to the pupils which are faced in everyday life and technologies, and which are specific, interesting and useful, and can reflect phenomena of real life unmistakably. By the usage of context-oriented approach and analysis of the problem to be explored, it is possible both to ensure the acquisition of general concepts and laws of physics and to develop learning skills, systematic thinking, thus improving general competence of the pupils.

**The chapter 1.3.** includes three subchapters in which the acknowledgements about the didactical model of reconstruction in the learning process of physics are analyzed.

**In the subchapter 1.3.1.** by analyzing the acknowledgments of different authors (Kattman, 2004, 2007; Kattmann et al., 1997), the authors conclude that the model of didactical reconstruction is like a base to unify the professional and educational competencies in research and learning process. The model is aimed at explaining theoretical structures and methods of the lesson, as well as explaining the planning, realization and reflexion of learning process. It also allows to describe the role and function of didactical conception from teacher's viewpoint. The components of physics didactical reconstruction consist of:

- 1) analysis of physics content structure, that includes two connected processes – the definition of the subject and the analysis of the meaning of education (Driver & Ericson, 1983);
- 2) the studies of learning and teaching, that contain the empirical research of the specifics of learning environment;
- 3) the developments and evaluations of instruction tie together with instructional material, designing learning activities, teaching and learning process in physics (Duit, Komorek, & Müller, 2004).

**In the subchapter 1.3.2.** it is defined that the goal of the model of didactical reconstruction is to provide a framework to plan and research a physics lesson, which is student-oriented, constructive from the viewpoint of learning theory: students have to construct their own knowledge while they are, for example, experimenting on their own. Students have to be given the opportunity to gain their own experience during the lesson. The student's ideas about the knowledge of specific physics topics is also a topic for didactical research. In the model of didactical reconstruction of physics they have a central role in planning a lesson. The main goal of didactical structuring in lesson is a systematic coordination of professional explanation with the student's understanding of the topic, acknowledgements of student's ideas and previous knowledge about physics.

Besides, the complications that could occur during learning are included in the planning (Kattmann et al., 1977).

**In the subchapter 1.3.3.** the authors conclude that didactical reconstruction is focused towards the reconstruction of physics knowledge in order to help the students understand the most important parts. The common goal is to identify the connections between physics knowledge and alternative every-day systems of students (Kattman, Duit, & Gropengießer, 1998; Duit, Gropengiesser, & Kattmann, 2005). Physics knowledge is a result of abstraction and reduction processes, but physics teaching includes making the science viewpoint understandable for the student. The model of didactical reconstruction in learning is based upon theoretical explaining of lessons' methods and structures, it connects the elements of planning and leading a lesson in a systematic relevance. The author concludes that the main components of the model of didactical reconstruction is content analysis, empiric analysis of learning environment, projecting of physics learning process. In the model of didactical reconstruction physics curriculum is made more approachable to the students, despite it being more complex because it is included in different contexts and interacts with the students' learning capabilities.

**The chapter 1.4.** includes two subchapters in which acknowledgements about neurocognitive learning theory and methods of neurovisualization are analyzed.

**In the subchapter 1.4.1.** the authors conclude that the theory of neuroscience and research in education pay a lot of attention to the science of learning and teaching, emphasizing the cognitive theory and perspectives of constructivism. Neurocognitive learning theory is a synthesis of 3 different directions:

1. Neurophysiology, with an emphasis on biological basis, activities of brain and nerves
2. Cognitive science, focusing on the experience of information processing and internal representation.
3. Learning theory, that explains how, in general, people interact and adapt in different environments.

These ideas emerged in the second part of 20<sup>th</sup> century by integrating the model of neurocognitive information processing in context – students think that they are learning scientific ideas by using verifications (Anderson, 2009). Cognitive research analyses the qualitative characteristics and thinking processes. It is based upon the model of processing information, that is used in cognitive psychology, which describes a person as an active and targeted recipient, the

processor of information and the creator of information. Learning is an active processing of information. Constructivists emphasize students' learning and understanding as an activity not as information of outer world. (Fox, 2001). Learning depends on many factors. From the viewpoint of constructivism the deciding factors are the student's initial assumptions and experience, the character of information and context in which learning happens. In accordance with constructivism the most important role of the teacher is to create a learning environment in which student has the opportunity to analyse his/her previous experience and knowledge, be active acquirer of knowledge and process new information in a real and meaningful context.

**In the subchapter 1.4.2** by analysing the methods of neurovisualization the authors conclude that visual perception is dominant in students starting from the pre-school period. Students gradually acquire the ability to perceive the colour, size, shape, proportions, frontal perspective of an object. In psychology it is also known that visual perception is the primary one. This characteristic should be taken note of in all subjects (Hibnere, 1998). Physics is also easier perceived by the use of models, theory of visualization, by showing that physics is the connection between theory and praxis.

By analysing theory of neurocognitive learning, the authors concluded that neuroscience provides synthesis between the theory of neurocognitive learning which explains how people generally interact and adapt in different environments, and cognitive science, that focuses on the processing of information and experience. The construction of knowledge occurs in connection with new information, we create new knowledge using assimilation and accommodation by including models of constructivism. Student must not acquire information passively, but learn from the surrounding environment by connecting the system of brains and intellectual environment in order to coordinate inner and outer world. The main learning method of a student is context-dependant learning, where problems and situations topical to the student are used to include specific scientific content or problem tasks, and is connected to the neurocognitive model.

**Chapter 1.5.** includes two subchapters in which physics curriculum of secondary schools and inclusion of bionics elements into physics curriculum.

**In subchapter 1.5.1.** by conducting research on standards of learning physics, books of secondary school physics and other sources of literature, the authors conclude that physics curriculum is structured in here blocks – environment, society, technologies. In physics standard learning of research activities is emphasised, which includes work with information, predictions, planning of the experiment, experimenting, data processing and analysis,

introduction to acquired results. One of the tasks of the subject is to develop scientific thinking and improve the skills of research activity and cooperation in physics. In physics, the clarification of laws and diversity of phenomenon happens through scientific quest: by observing, experimenting, measuring, modelling, working with sources of visual and verbal information and using information technologies. Therefore a modern curriculum contains not only abilities and skills but also scientific methods in acquiring content. This block is structured according to the directions of the researcher:

- Development of skills of acquirement, the use of mathematical models and other cognitive actions,
- Development of experimental skills,
- Work with verbal and visual sources of information (communication skills, the use of information technologies),
- Development of skills of cooperation.

**In the subchapter 1.5.2.** the authors clarify that bionics is based upon the idea that the optimal solutions of practical problems must not be figured out anew – nature has solved them in an almost 4 billion year-long process which is called evolution. Supporters of bionics assume that nature is the main source of ideas and innovation. Nature is the world's most influential engineer, smartest physicist – provides countless ways how to create new and improve existing mechanisms using small, simple, inexpensive methods. For example flies and sea hedgehogs have vacuum suction cups, because of which the sea hedgehogs can climb very steep cliffs and flies – walk on the ceiling. Nature has gifted spiders with a hydraulic drive, that allows to move very quickly. (*Ищенко, 2008*). By experimenting the student creates understanding of the functioning of biological system, the student can model functional, technological solutions, seek the connection between nature and technology, seek a solution on how to improve the current ecological situation. The creation of connections between nature and technologies is a perspective way how to improve the ecological situation by developing harmony between nature and technology and development of such mechanisms and technologies that are nature-oriented. Author offers to integrate elements of bionics in the physics course in the corresponding topics.



### **The Improvement of Physics Methodics for the Development of Students' Natural Studies and Technologies Competence and Promotion of Acquirity Interest about Natural Sciences**

In part 2 natural studies and technologies competence, didactical model of learning physics and criteria for its evaluation are described.

**In the subchapter 2.1.** the authors conclude that if students would be involved in the research of science problems in the context of real life, then the development of competency of natural studies and technologies competence is possible within a didactical model that integrates the student's knowledge about nature. Scientists (P. Perenoda, J. Kulahan, I. Maslo and I. Tiļļa) connect competence to the students' abilities to function in defined conditions, basing on knowledge, function effectively in given situations as well as the ability to gain experience.

Acquisition of nature studies and technologies is often related to basic competence; includes a capacity to apply scientific knowledge, formulate questions and draw substantiated conclusions to understand and help make decisions on the nature and changes in it caused by human action (Key competencies, 2002). The European Parliament and Council have adopted recommendations for basic skills in lifelong education. This document among the key competences mentioned the competence of nature studies and technologies. Competence in nature studies refers to the ability and wish to apply knowledge and methods to explain the world of nature, identify questions and draw substantiated conclusions. The competence of technologies is considered to include knowledge and methods needed perceiving human wishes and needs. Nature studies and technologies competence also includes understanding of human caused changes in natural environment and responsibility each member of society shall undertake (Mūžizglītības galvenās pamatprasmes, 2007). Competence shall be perceived as a set of knowledge, skills and attitudes needed for taking action (Tiļļa, 2003). The development of nature studies and technologies competence is necessary for personal growth and inclusion into society to apply consciously modern technological products, discuss on the progress of science and technology, and work in the field of natural sciences and engineering. Nature studies are a significant product of public culture an element of the world outlook, thus, it is natural for every educated person to be aware of the natural science thought. Exploration of scientific cognition of natural phenomena and formation of understanding are significant already at school. Acquiring natural sciences pupils get what is needed to increase their

understanding of the surrounding world. Sciences highlights the link between a human being and nature, it facilitates pupils' strive for knowledge, critical view and reminds of restricted use of natural resources (Science Teaching in Schools in Europe, 2006).

The process of learning physics at school is significant in world cognition. It is essential to increase the effectiveness of teaching physics and promote the attractiveness of this subject because:

- it provides understanding of science to pupils who shall become full-fledged members of technologically developed society;
- it encourages young people to devote themselves to the career in the field of science.

Natural studies and technologies competence can be attributed to the ability and willingness to use knowledge and methods in order to explain the world, make conclusions based upon evidence by using knowledge and methods according to the persons wishes and needs.

**In the subchapter 2.2.** the authors have developed a context-oriented didactical model, that includes students' knowledge about the nature for physics learning, the idea of which is connected to the integration of elements of bionics into physics curriculum therefore providing the unity of learning, nature and technology and realising the learning process in a social dialogue and interaction with nature and technologies (Figure 1). This mentioned model foresees a more effective acquisition of physics knowledge, a deeper understanding of physics curriculum, the interaction between nature and technology, the use of physics knowledge, the development of abilities of scientific enquiries, enrichment of positive emotional attitude, development of expressions of scientific reflexion. Theoretical basis of the model is based upon the theory of constructivism that explains that learning is a process of constructing knowledge which is in turn based in social interaction, student's previous experience of student working with context-oriented, systematically created curriculum that integrates the student's knowledge about nature (Figure 1).

In the developed didactical model of learning physics it is expected to view the interaction- dialogue, „student-teacher”, „student-student”, „student-nature”, „student-technology”, by activating previous experience, widening the abilities to use knowledge by developing research skills. The use of these interactions in the learning process of physics spark students' interest, draws attention, activates students' learning activities, connects learning process to practical life. By including bionics in physics curriculum, the biological system and the

technological solution of this system is viewed in context, which allows praxis to be used in theory and vice versa.

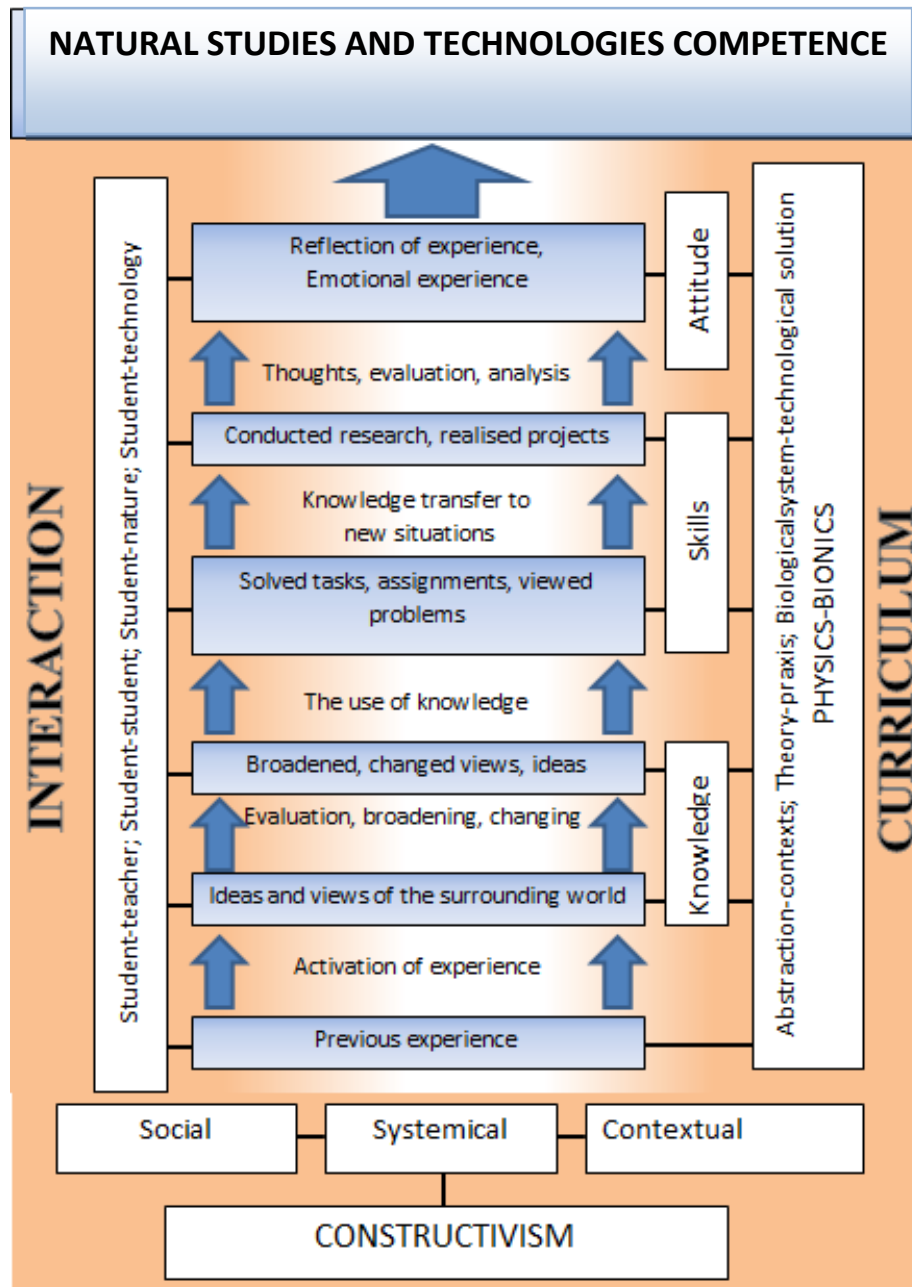


Figure 1. Didactical model for acquisition of physics that integrates student's knowledge about nature

**In the subchapter 2.3.** the authors have concluded that physics learning is guided towards learning integrated knowledge about nature and is to be realized in a context-oriented pedagogical process, where student has an important role in gaining knowledge. The learning process is guided towards the facilitation of the

development of natural studies and technologies competence. Natural studies and technologies competence can be perceived as a collection of knowledge, skills and attitudes, that are required to explain the surrounding world, perceive problems, analyze and solve them in a research work in order to understand processes of nature and changes in nature, evaluate them and act accordingly. That means that criteria for development of natural studies and technologies competence can be considered: knowledge, skills, attitudes.

In order to explain physical processes and phenomena, to solve tasks pupils need solid knowledge background. Precise and broad factual knowledge lets involve students more successfully in solving tasks and problems which are crucial in scientific cognition. In the learning process thinking shall be focused on deeper understanding of the new knowledge. Understanding is considered to be a significant characteristic of learning related to the acquisition of notions, laws and theories when the meaning and understanding of the learnt material form in pupils' consciousness. A significant aspect is also formation of understanding on the interaction of nature and technologies creating links between animate and inanimate nature, thus making learning situations meaningful and providing an opportunity to construct new knowledge from authentic experience. Understanding is related to structuring the existing experience with new information. Understanding of phenomena, processes and objects means revealing significant aspects and abstracting the insignificant aspects. Table 2 includes the indicators of the criterion of nature studies and technologies competence development – knowledge – and the characteristics of their expression on three levels.

Table 2 **Indicators of the criterion of nature studies and technologies competence development – knowledge – and the characteristics of their expression**

<b>Criterion</b>	<b>Knowledge</b>	
<b>Indicators</b>	<b>Understanding of notions, laws, theories</b>	<b>Understanding of interaction between nature and technology</b>
<b>Description of levels</b>	<b>Low level – REPRODUCTIVE KNOWLEDGE</b> The skills characterizing the aspects of understanding are expressed episodically, sometimes a positive result is observed. Knowledge is reproduced, it is based on memory, a reproductive thinking level. Reading or listening and retelling are typical.	

	<p><b>Average level – INTERPRETING KNOWLEDGE</b></p> <p>The skills characterizing the aspects of understanding are sufficiently developed, they are demonstrated by partially positive results. One is able to analyse situations, explain the nature of phenomena and processes, the course of their development. There is observed insufficient understanding of some more detailed issues; however, there is tendency to move to deeper understanding.</p>
	<p><b>High level – PRODUCTIVE KNOWLEDGE</b></p> <p>Knowledge is acquired, skills are developed in compliance with the requirements of physics standards at secondary school. The skills characterizing the aspects of understanding are shown they are consistent. Knowledge is systemic, classified, applicable and dynamic letting to see the aspects of interaction between nature and technology.</p>

The acquired knowledge shall be applicable. The relation of physical processes and phenomena learnt in physics to practical life, their applicability in nature and technology are indisputable, therefore, it is significant for pupils to be aware of these phenomena and be able to apply them in various areas. Knowledge, which people do not use, are not able to apply, has no value; therefore, in the learning process it is essential to make knowledge not only consistent and broad, but also applicable in practice.

Application of knowledge facilitates freer acquisition, induces learning motivation revealing the practical significance of the issues to be learnt, brings knowledge closer to life and understood really, not abstractly. Formation of skills to apply knowledge is gradual when a teacher directs pupils from knowledge application according to a sample to independent creative activity, thus teaching pupils to control the solution of the task by themselves, to analyse the causes of success and failure. Inducing thinking operations a teacher should make pupils form knowledge application skills in non-standard situations. Such level of knowledge application skills is typical for a productive activity where pupils are ready to solve scholastic problems, reveal objectively new relationships, formulate general conclusions and are able to transfer knowledge to solve new tasks. Interpreting activities are oriented towards the skill to apply knowledge by analogy or in known situations. Operating with known assumptions pupils define relationships, use factual material to explain and prove. The lowest level of knowledge application is typical for reproductive activity when knowledge is applied by a sample. Quite often knowledge is memorized mechanically, thus, making them hard to be applied in solving scholastic tasks in the learning process and in real life.

Pupils acquire knowledge from various sources, thus, it is essential to help them structure knowledge, master the skill to apply them. Table 3 includes the indicators of the criterion of nature studies and technologies competence development – skills – and characteristics of their expression on three levels.

Attitudes also influence the formation of nature studies and technologies competence basing on the acquired knowledge and developed skills. In its turn, attitude is based on the ability to learn, realised opportunities and a self-critical approach (Žogla, 2001). Attitude is related to pupils' interests, motives, views and beliefs. In V.McGuire's opinion attitudes include cognition, emotions and verbal and non-verbal action (McGuire, 1985; Ajzen, 2005). Basing on the cognition mentioned above emotional experience and reflection can be distinguished as significant factors of attitude. Learning include the presence of adequate emotional experience, evaluation of one's own action and knowledge, contemplations about the surrounding world and the role of science in the society in the development of technologies.

**Table 3 Indicators of the criterion of nature studies and technologies competence development – skills – and characteristics of their expression**

<b>Criterion</b>	<b>Skills</b>	
<b>Indicators</b>	Knowledge application skills	Scientific cognition skills
<b>Description of levels</b>	<b>Low level – REPRODUCTIVE ACTIVITY</b> Pupils are able to complete scholastic tasks by a sample, but do not understand their meaning fully. Observation and reproduction are typical activities.	
	<b>Average level – INTERPRETING ACTIVITY</b> Pupils are able to apply knowledge by a sample in similar situations. They are able to solve typical and combined scholastic tasks. Activities with information by interpreting it, making schemes, models and applying it in standard situations are typical.	
	<b>High level – PRODUCTIVE ACTIVITY</b> Pupils are able to apply knowledge independently in creative unfamiliar situations. Logical thinking, independent judgments, original approaches are developed. Pupils are able to solve not only basic scholastic problems, but also transfer knowledge and skills to discover new relationships and solve technological problems.	

Acquisition of physics depends on the level of pupils' emotional development. Emotions influence human's behaviour, capacity, increase or decrease of activity. Joy, friendly cooperation, and excitement increase capacity.

Such emotions increase the activity of the whole body, and general tonus of the nervous system. However, concern, fear, shame influence depressively, weaken bodily processes and reduce energy. These emotions make people to be inert, inclined to inaction (Čehlova, 2002).

Emotional experience is a condition and kind of emotions and feelings experience. Attitudes towards phenomena, actions and objects depend on the character and depth of emotional experience. In the learning process of physics pupils' interested attitude, expressions of emotional experience can be observed:

- acquiring new information containing a surprise element;
- demonstrating impressive experiments by a teacher;
- providing an opportunity for pupils to plan, prepare and implement experiments;
- showing opportunities how pupils could use their energy and capacity;
- revealing expressive solutions to problems by a teacher, highlighting the visual attraction of equipment and models;
- listening to persuasive judgments;
- working on independent researches resulting in the joy of discovery.

I. Žogla indicates that it is easier for pupils to learn and learning activities are more productive if positive emotions dominate. On the background of a positive emotional attitude episodic failures, embitterment cause a wish to learn, correct the mistake, prove to oneself and others one's abilities (Žogla, 1994). Optimal balance between positive and negative experiences, when positive ones dominate, but negative ones train pupils persistence and willpower, lets them use the reserves for promoting pupils' intellectual productivity.

Reflective activity shall also be facilitated in learning physics. It lets look at the completed tasks and serves as background for further development. Z. Rubene explains reflection as an ability to think critically and make independent critical judgments (Rubene, 2004). Reflection is related to analysis, critical evaluation of thoughts and judgments, active restructuring of knowledge and opinions (Rubene, 2009). It is human's self-actualization, perception and contemplation of one's own feelings and thoughts (Garleja, 2003). Developed reflection skills provide pupils understanding of the level of their nature studies and technologies competence and the necessity to improve it. Reflective includes contemplation, self-evaluation, analysis of personal thoughts and experiences; it is exchange of thoughts and emotions.

Emotional experience and reflection have typical expressions – from practical activity, contemplation on specific achievements and experiences to

transition to mental experience, personal significance and self-analysis. Table 4 includes the indicators of the criterion of nature studies and technologies competence development – attitude – and characteristics of their expression on three levels.

Table 4 **Indicators of the criterion of nature studies and technologies competence development – attitude – and characteristics of their expression**

Criterion	Attitude	
Indicators	Emotional experience	Reflection
<b>Description of levels</b>	<b>Low level – SITUATIONAL ATTITUDE</b> Pupils experience social effects in the learning environment – praise, joy for achievements, evaluation, overcome difficulties and fear. The gained experience is reflected in emotions and feelings.	
	<b>Average level – HABITUAL ATTITUDE</b> Pupils experience intellectual achievements. Negative emotions are the basis of work to eliminate the causes of failure. Pupils see the meaning of practical and intellectual activities in their growth and have positive experience. Contemplation about learning activities and awareness of one's emotional reactions are typical.	
	<b>High level – SELF-REGULATED ATTITUDE</b> Pupils experience the results of self-control and self-analysis, broadening intellectual abilities, the results of independent cognitive activity, development of skills for practical application of knowledge. Self-actualization expressed in critical analysis of one's activity and knowledge, contemplation on the meaning and extents of knowledge.	

Therefore, learning physics can be considered as pupils' active purposeful activity for the activation of their experience and further enrichment in systemically organized environment acquiring knowledge with understanding, applying them in various situations in the social and functional context and activating emotional experiences and motives, expressing reflection of experience based on topical contemporary needs.

### **Analysis of the Efficiency of the Didactical Model that Integrates Student's Knowledge about Nature for Acquisition of Physics**

Part 3 describes the empirical research.

**In the chapter 3.1.** the way of research is described, the methodology of quantitative and qualitative research. During the practical research the authors



clarified the level of awareness of the students and teachers about bionics and the transfer of natural processes to technology, tested how the use of the didactical model that integrates the student's knowledge about nature in the learning process affects physics learning in secondary school, evaluated the level of students' acquired physics knowledge and skills by the end of the pedagogical research, evaluate the change of attitude towards physics by the end of the pedagogical experiment.

By analysing the level of students' learning, extra attention was paid to these aspects: student's acquired knowledge, the understanding of theory, laws and ideas, as well as the understanding of the interaction between nature and technology, knowledge skills, skills of scientific research, analysis of knowledge and actions, attitude.

**In the chapter 3.2.** analysis of the acquired data and results has been done. The main results of the empirical research:

Students see the connection between the events happening in nature and the development of technology, despite the fact that the physics course does not mention that many technological solutions are based upon natural processes;

Students want the teachers to use visualization in the teaching process – presentations, demonstrations;

Students would love to have more examples of nature and the explanation of physics laws using the laws of nature;

Students enjoy researching, making conclusions, use the previously acquired knowledge, experience, but students do not associate it with the transfer of natural systems to technological constructions;

A positive change in students' attitude towards physics can be achieved via the use of the didactical model that integrates the students' knowledge about nature.

By fulfilling the previously set goals, the authors have come to a conclusion that the previously set hypothesis is confirmed. The use of the developed didactical model and the use of elements of bionics in physics learning process, raises the students' interest in physics and sciences, develops competency of science and technology more efficiently.

## **Conclusions**

- In physics didactics, a context-oriented approach, that is focused towards an actively working student, which is constructing an understanding of physics content with the help of contexts, can be brought forward as a topicality.

Context-oriented learning is connected to the creation of a new learning culture, that is focused on promoting student's scientific thinking, by advancing the understanding of scientific work about topics that integrate everyday events, natural phenomena, processes of technology and production.

- Physics curriculum is to be improved by integration of bionics elements that provide the unity of learning, nature and technology and facilitates the students' thinking in connections, by connecting theory and praxis, biology and physics, biological systems and technological solutions.
- Physics learning can be realised basing upon a didactical model that integrates the student's knowledge about nature which is based upon the theory of constructivism and proposes learning in a social interaction, basing upon previous experience, actively working with a context-oriented, systematically created curriculum, developing the natural studies and technologies competence.
- The model actualizes the didactical laws and ensures the usability of students' knowledge skills, the development, systemicness and usefulness of attitudes, that allow to see the aspects of interaction between nature and technology, uncover new links to solve technological problems.
- Natural studies and technologies competence can be perceived as a complex of knowledge, skill and attitude, that are required to explain the surrounding world, to perceive problems, analyse and in active research work solve them, to perceive the changes in nature, evaluate them and react responsibly.
- The development of competency of nature research and technology in physics learning process show the formation of understanding of physics, the interaction between nature and technology, the improvement of the usage of physics knowledge and the skills of scientific research, the creation of positive experiences and the development of thinking skills
- The didactical model of teaching physics that integrates student's knowledge about nature has shown positive results by contributing to the creation of a deeper understanding of physics theory, the interaction between nature and technology, the development of the use of physics knowledge and the skills of scientific reflexion, the enrichment of positive emotional attitude and the development of scientific reflexion.
- The developed approbation of the didactical model of physics teaching that integrates student's knowledge about nature, points toward the fact that context-oriented learning process and the use of bionics elements in the

secondary school physics curriculum, improves the students' interest in physics and sciences, develops the competency of science and technology more efficiently.

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